Drop and Towed Camera Systems for Ground-Truthing High Frequency Sidescan in Shallow Waters

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DROP AND TOWED CAMERA SYSTEMS FOR GROUND-TRUTHING HIGH FREQUENCY SIDESCAN IN SHALLOW WATERS

by

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ABSTRACT

Vandermeulen, H. 2007. Drop and towed camera systems for ground-truthing high frequency sidescan in shallow waters. Can. Tech. Rep. Fish. Aquat. Sci. 2687: v + 17 p

The specifications and design of a drop and towed video camera system are described for shallow water use. The drop camera is a downward looking 'quadrat' camera useful for quantifying objects seen in the frame. The towed camera offers rapid 'transect' views of the bottom useful for describing habitat classes. All video is georeferenced to dGPS specifications (sub-meter precision) and stored as digital video clips in ArcGIS projects which include camera tracks (towed camera) and point locations (drop camera). Both camera systems are used to ground truth high frequency sidescan images (800 kHz, 30m swath).

RÉSUMÉ

Vandermeulen, H. 2007. Systèmes de caméras larguée et remorquée établissant la réalité de terrain de balayages latéraux à haute fréquence en eaux peu profondes). Can. Tech. Rep. Fish. Aquat. Sci. 2687: v + 17 p

Le document décrit les spécifications et la conception de systèmes de vidéocaméras larguée et remorquée en eaux peu profondes. La caméra larguée est une caméra « quadrat » à détection plongeante utilisée pour quantifier les objets affichés sur les images. La caméra remorquée fournit des vues transversales rapides du fond servant à décrire les classes d'habitat. Toute la vidéo est géoréférencée par rapport aux spécifications du DGPS (précision submétrique) et stockée sous forme de vidéoclips numériques dans le cadre de projets ArcGIS comprenant des trajectoires de caméra (caméra remorquée) et des emplacements ponctuels (caméra larguée). Les deux systèmes de caméra permettent d'établir la réalité de terrain correspondant à des images obtenues par balayage latéral à haute fréquence (800 kHz, couloir de 30 m).

INTRODUCTION

The structure and function of nearshore habitats has become a topic of interest recently for managers of the marine environment. Decisions are more often being made within the context of ecosystem principles, rather than upon impact or resource specific requirements alone. Researchers within the Science Sector of the Department of Fisheries and Oceans (DFO) are now frequently asked to describe, or map, bottom features such as habitat patches to feed into management requirements.

The equipment and methods required to map mid or deep water areas (e.g. 100m) are relatively well established. Commercial camera systems, echo sounders, cable and reel systems are available from a number of large companies for that purpose.

This is not the case for shallow waters. For example, only a few companies make echo sounders that function well in shallow (<10m) water for the purposes of bottom mapping. The following text describes the results of a three year quest to find the parts and build an inexpensive mapping system for shallow waters. The intent was to map at a bay wide scale (10s of km), which excludes SCUBA based survey methods.

Camera systems offer a relatively simple method to make bottom observations for nearshore marine studies to augment (or replace) SCUBA surveys (e.g. Strong and Lawton 2004). For the purposes of this paper, when a camera is deployed over the side of a vessel with its support line held near vertical and the intention is to view a particular point on the bottom (i.e. the camera is not actively towed at speed along a particular track), then the camera is being used as a 'drop' camera (e.g. Kostylev et al. 2001). In general, the position of a drop camera is accepted as vessel position, or reasonably close to it.

When a camera is actively pulled through the water, frequently along a predetermined transect (i.e. its support line may be at an angle), it is considered to be a towed camera. The towed camera position relative to the support vessel may be considered in two possible ways:

1) 'close enough' to vessel position so that the position error is not important (e.g. Jordan et al. 2005);
2) significant difference between camera and vessel position, so 'true' camera position must be determined via –
    a) calculations such as layback (e.g. Hewitt et al. 2004)
    b) an acoustic positioning system (this paper)

A drop camera and an acoustically positioned towed camera system are described here for shallow water use.

2.0 MATERIALS AND METHODS

2.1 Vessel

All equipment has been custom fitted to a 22' Cape Sable style Rosborough wheelhouse (Figure 1). This sturdy fiberglass vessel has a 46cm draft with small (50hp) twin engines for controlled towing at slow speeds. Prop protectors have been installed to avoid cable entanglement. The propellers are above keel depth, so the boat can travel in very shallow water (<1m). The wheelhouse offers a dry and secure space for electronics.

A light weight davit was installed on the port side of the stern working deck. Custom blocks were built for each camera system used (details below). The davit is also the mounting point for the dGPS antenna.

All positioning data is obtained from a Trimble® DSM™ 132 differential GPS with beacon correction. Data streams are to five decimal places of minutes, and the placement precision is ±20cm at best[1]. Vessel navigation (including targets and predetermined transects) is performed via a notebook computer at the helm running Fugawi™ software with CHS approved chart packages.

A 'break away' arm was designed and built to be attached to the base of the davit (Figure 2). The arm is held vertically in line with the davit while underway and actively recording data. An instrument mounted on the arm is therefore directly under the dGPS antenna. The arm is mounted at the base of the davit with a pivot point and spring tensioned clamp to allow the arm to swing backwards and upwards if an obstacle is struck while underway. The arm is used to hold the towed camera positioning transceiver (details below) or a sidescan towfish.

An Imagenex[2] SportScan dual high frequency sidescan (330 or 800 kHz) is used to map three dimensional bottom features (rock reefs, eelgrass, debris, pits, etc.) and provide an indication of bottom hardness (soft bottoms are acoustically 'dark' while hard bottoms provide a strong, bright return signal). The depth rating of the SportScan is 30m. The SportScan is typically run at 800 kHz and 8 dB gain with a 30m swath width to provide the best possible image detail. The towfish is not particularly stable when towed, which is why it's mounted to the break away arm. The arrangement also allows the sidescan to be used in shallow water (approximately 1m) and still attain the full 30m swath width. Sidescan data is post processed by a georeferencing software package[3] to generate GeoTIFF images that are embedded into ArcGIS projects with hydrographic chart background layers.

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[1] This was tested by placing the antenna at a fixed point on shore and recording latitude / longitude coordinates over approximately 15 minutes. The test was repeated several times on different days. The random drift in the data stayed within approximately 20cm (i.e. fifth decimal place of minutes varied while fourth decimal place stayed steady).

[2] Port Coquitlam, British Columbia.

[3] SonarWeb Pro sidescan mosaic software – Chesapeake Technology Inc., Mountain View, California.

All onboard electronics are powered by a deep cycle battery / gel power pack system (Figure 3). Two deep cycle batteries are housed in a waterproof wooden box at the stern of the research vessel. A waterproof 12 volt line runs from that point into one of the two gel power packs[4] in a waterproof wooden box in the wheelhouse. That gel pack has an inverter to create 120V AC. The other gel pack supplies 12V DC. A waterproof metal switch box is bolted to the side of the power pack box.

2.2 Drop Camera

Sidescan images collected over one field day are typically ground truthed with a drop camera on the following day. The drop camera system was developed from an inexpensive 12 volt DC color camera which had been commercially modified for underwater use[5]. The camera and its light were custom fitted to a video feed / power cable for a maximum deployment depth of 40m. A wide plastic clothesline reel was modified into a block such that the cable (plus support rope) can be easily looped onto the reel, rather than threaded through.

A folding tripod was constructed to house the camera and light (Figure 4). Twin lasers[6] mounted on the tripod camera housing provide a 10cm scale along the line of sight, which is a vertically downwards view. Video clips taken with the camera cover a bottom area of 50 X 75 cm.

Once the vessel is on target, the tripod is lowered over the side by its support rope (and associated power cable) positioned in the block on the davit. Engines are reversed just prior to the tripod hitting bottom, to ensure vertical rope alignment. Therefore, the camera is directly under the dGPS antenna when video clips are collected.

A schematic of the sidescan and drop camera systems is given in Figure 5. Position data from the dGPS is sent to a video overlay[7] and added to the video stream from the camera, the output is recorded on a miniDV camera[8]. In this manner, each frame of video includes true camera position plus time and date stamp.

The miniDV tape format is digital, and the tapes are post processed into short clips (approximately 15s per camera drop) in AVI format to provide high resolution data (720 X 480). The AVI files are embedded as georeferenced clickable points in the same ArcGIS projects as the sidescan images.

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[4] Motomaster Eliminator Power Box, Canadian Tire.

[5] SeaMaster SuperMini 50 color camera (low light black and white) with SeaLite 50 (halogen, 130 watts) made by SeaView Video Technology (St. Petersburg, Florida).

[6] Trident underwater laser pointers for hand held SCUBA use (battery powered, rated to 50 m)

[7] Sea-Trak video overlay, three decimal places of minutes displayed. SeaViewer Underwater Video Systems, Tampa, Florida.

[8] Canon ZR90 miniDV camera

2.3 Towed Camera

A towed camera system was developed to assist with ground truthing the sidescan and for stand alone habitat classification work (Figure 6). A surplus Benthos depressor wing is the core underwater platform to which the camera is attached. The video camera is a moderately priced unit designed for underwater work[9]. It is depth rated to 600m, and is presently connected to 60m of high quality armored cable. The cable is looped over a custom made plastic clutch block (30.5 cm diameter) which will spin clockwise to allow the cable and wing to be pulled into the boat, but locks on counterclockwise spin as the cable is played out and over the side. The locking action of the clutch block holds the wing in position as it is towed, relieving most of the strain on the operator holding the cable. The wing is lowered via the cable slipping over the plastic surface of the locked block. There is just enough friction to slip the cable out as required and then to hold it in place for the tow. The operator makes slight angle changes to the cable relative to the clutch block to control the level of friction and 'hold'.

The camera is mounted under the wing on a metal plate with the same two laser pointers used on the drop camera tripod (i.e. a 10cm laser scale, Figure 6B). The camera and lasers are protected by a stainless steel cage bolted to the wing. The camera view is forward, with a slight downwards angle.

An acoustic positioning system was obtained in order to ensure accurate camera positioning relative to the vessel. The TrackLink 1500LC system[10] consists of a transponder strapped to the wing (Figure 6A), and a transceiver mounted to the break away arm (Figure 6C). The transceiver is therefore directly under the dGPS antenna during camera tows. The transceiver positioning accuracy is 3º, which is quite adequate in the shallow waters where the camera is deployed. Tow speeds are typically one or two knots.

A schematic overview of the towed camera system is given in Figure 7. The heart of the system is the transceiver computer which is a notebook equipped with multiple COM ports via PCMCIA cards. Position data from the dGPS is sent to the transceiver computer along with digital compass[11] and transceiver data feeds. The transceiver computer calculates true camera position and sends that data to the video overlay[12] for insertion into the video stream, as well as to a file that records the camera track over time.

The overlay output is recorded on a miniDV recording consul[13]. A separate feed from the consul goes to a video monitor so the camera operator can view the camera output in real time and pull on the cable to raise or lower the wing for appropriate

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[9] Shark Marine SV-16 underwater video camera. Burlington, Ontario.
[10] LinkQuest Inc., San Diego, California.

[11] KVH Azimuth digital compass, Middletown, Rhode Island

[12] Horita (Mission Viejo, California) GPT-50 video overlay. Display to four decimal places of minutes.

[13] Shark Marine SV-DV surface console

height off bottom and to avoid obstacles. Figure 8 shows the towed camera electronics in the wheelhouse.

The transceiver notebook computer is very sensitive to COM port inputs. Data streams must come in at the correct times and not be interrupted or the computer will hang or behave erratically (this is an issue with data acquisition via multiple COM ports on most computers). As a result, a specific start up sequence is used:

- Power up computer with all COM ports unplugged,
- Plug in and turn on all COM in / outputs,
- Start TrackLink software,
- Use 'test' to check data input streams from dGPS (COM7, 9600 BAUD, GLL format), digital compass (COM6, 4800 BAUD), and transceiver (COM4, 9600 BAUD),
- Wake-up transponder at its channel address,
- Turn on camera and video overlay to check COM1 output data (9600 BAUD, GLL format)

As per the drop camera, the miniDV tapes recorded with the towed camera are post processed into clips. However, the towed camera AVI clips are longer (approximately 10 minutes each). The AVI files are embedded as georeferenced clickable points along the camera tow line which is itself overlain in the same ArcGIS project as the sidescan images.

3.0 RESULTS

Figure 9 demonstrates the ability of the sidescan to detect objects on the bottom, in this instance artificial reef material (1m diameter rock piles) in shallow water on a sandy / silty bottom in Sambro Harbor, Nova Scotia. The sidescan can resolve objects to about 10cm, and some of the individual rocks in the piles show up as bright specks. The rocks are 10 to 20cm in diameter. The dark center portion of the swath is an acoustic 'shadow' created by having the sidescan towfish mounted on the break away arm, well above the sea floor. If the towfish was towed at depth, the shadow would be reduced in size.

Both the drop camera and towed camera systems were deployed to ground truth the sidescan images taken through the reef material in Sambro Harbor. Figure 10 is an image from the drop camera taken on the soft bottom outside of the reef piles, corresponding to the dull brown featureless regions of the sidescan image. This screen shot contains far less information than the actual video clip recorded. When the clip is viewed, the algal material is more easily resolved and can be seen moving back and forth in the surge against the static grey colored bottom.

Figure 11 is a screen shot from a towed camera pass through one of the reefs. The top line of the video overlay indicates true camera position, in this case 44º 28.1691' north latitude by 63º 36.0681' west longitude. The second line down is a time stamp

generated by the transceiver computer; it is useful for editing video clips. The bottom line shows internally (hence the 'I') generated time and date stamps from the video overlay.

DISCUSSION

By focusing upon the precision of georeferenced data (i.e. the use of a high end dGPS and the TrackLink), a group of reliable and accurate systems (sidescan, drop and towed cameras) have been developed to work together to produce high quality information for benthic habitat mapping. Both the towed camera and drop camera systems adequately ground truth sidescan images, and have a role in describing nearshore benthic habitats on their own. The value of the drop camera is its ability to act as a quadrat sampler, to allow quantification of the image (i.e. count organisms, or measure cover of macrophytes, etc.). The towed camera system acts as a transect sampler, it provides an overview of habitat groups (e.g. urchin on cobble, or eelgrass on sand) over long strips of the bottom.

The sidescan and camera systems were developed to map nearshore habitats on a limited budget. The capital expenses (approximately $60K in total, excluding the vessel) were far lower than similar systems used for deep water off large vessels. Since all information is in digital format, the operating costs are limited to boat fuel and operator time.

ACKNOWLEDGMENTS

Paul Keizer and Tom Sephton provided the vision and support for the development of a nearshore mapping project at the Bedford Institute of Oceanography (BIO). Sean Steller suffered many hours at the helm and in the lab to help make it happen. A special thank you to Glyn Sharp, who fearlessly allowed me to rip into his brand new video gear and turn it into a towed camera system.

Funding for equipment purchases came from Science Branch and the Oceans & Habitat Branch at BIO. Custom design for equipment modifications, tripod, towfish and vessel support hardware was provided by Dan Moffat and Glen Morton (Ocean Sciences Division). Wiring and debugging COM ports and software was lead by Morley Wright and the team at Integrated Technical Services, Canadian Coast Guard. As always, the staff working in the BIO welding, machine and carpentry shops did a superb job of turning paper plans into reality.

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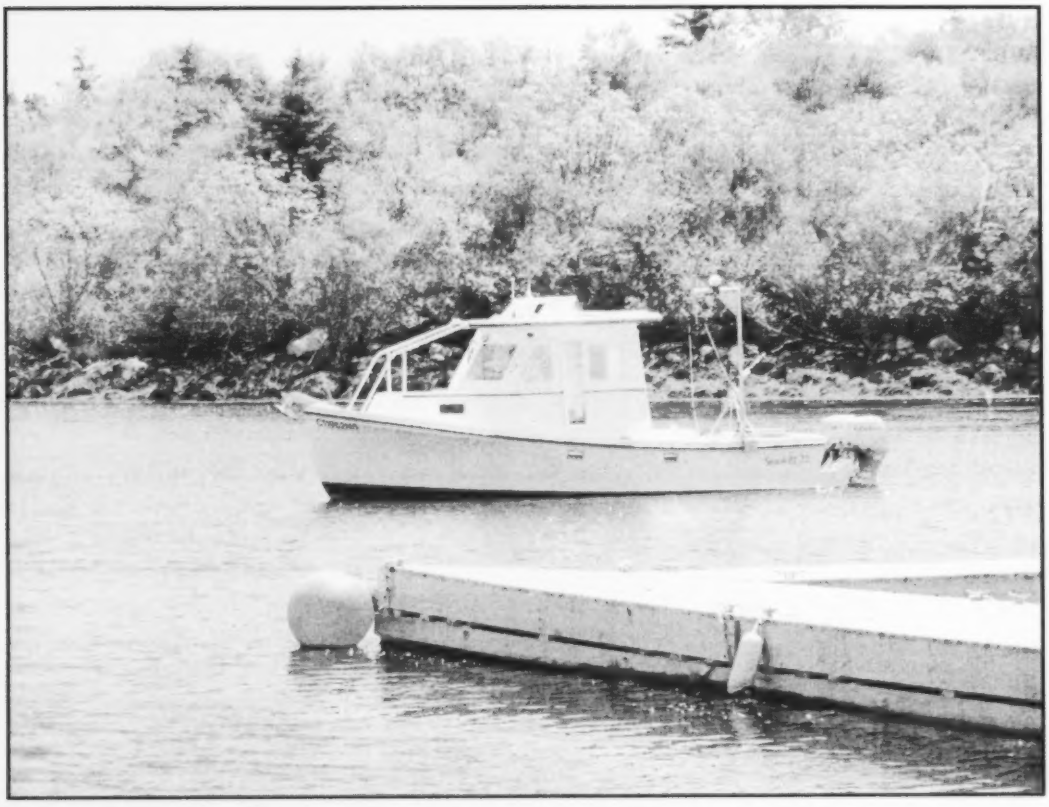

Figure 1: 22' research vessel, note davit post in stern deck area with white dGPS antenna dome on top.

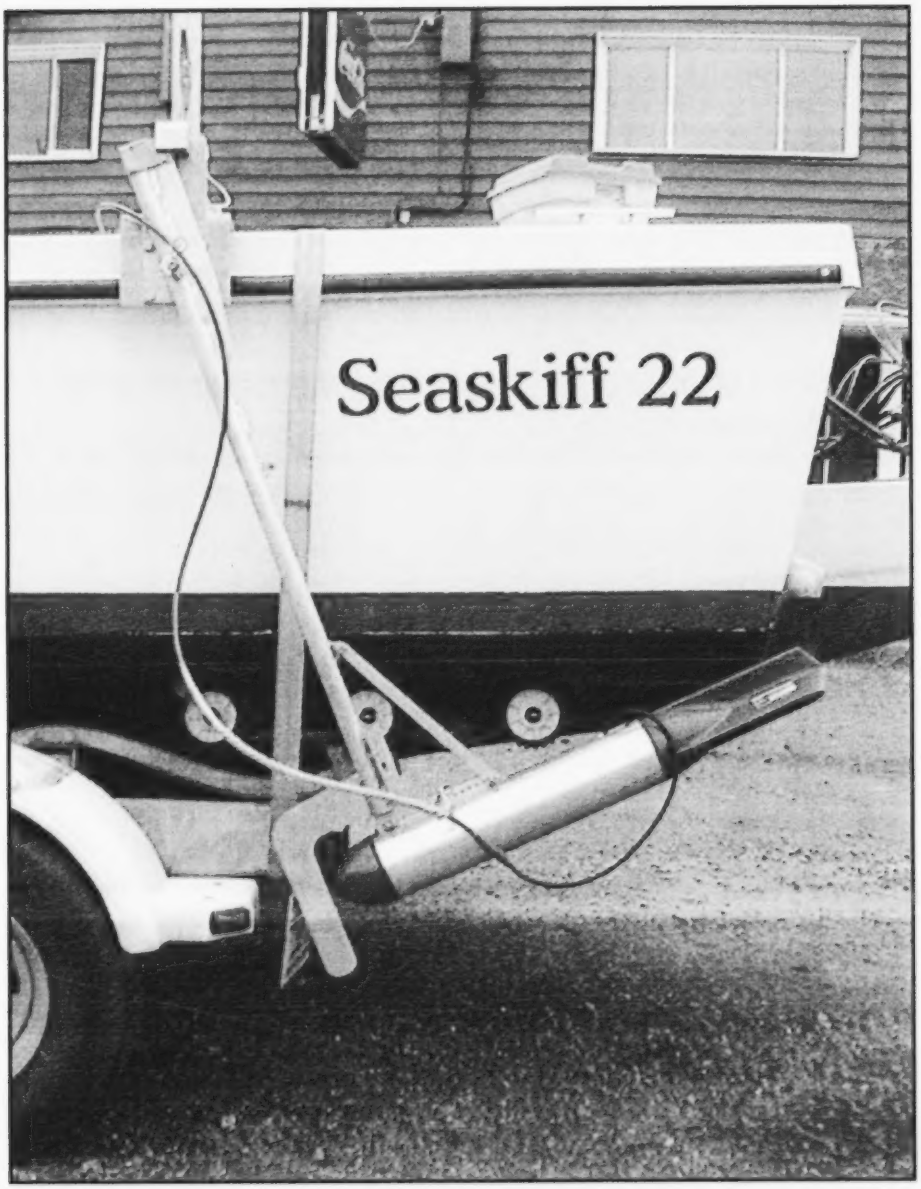

Figure 2: 'Break away' arm with sidescan towfish. The arm is typically in a vertical position during transect runs. The inverted 'L' aluminum plate at the base of the arm (in front of the red nosecone of the towfish) takes an obstacle, or bottom hit, first.

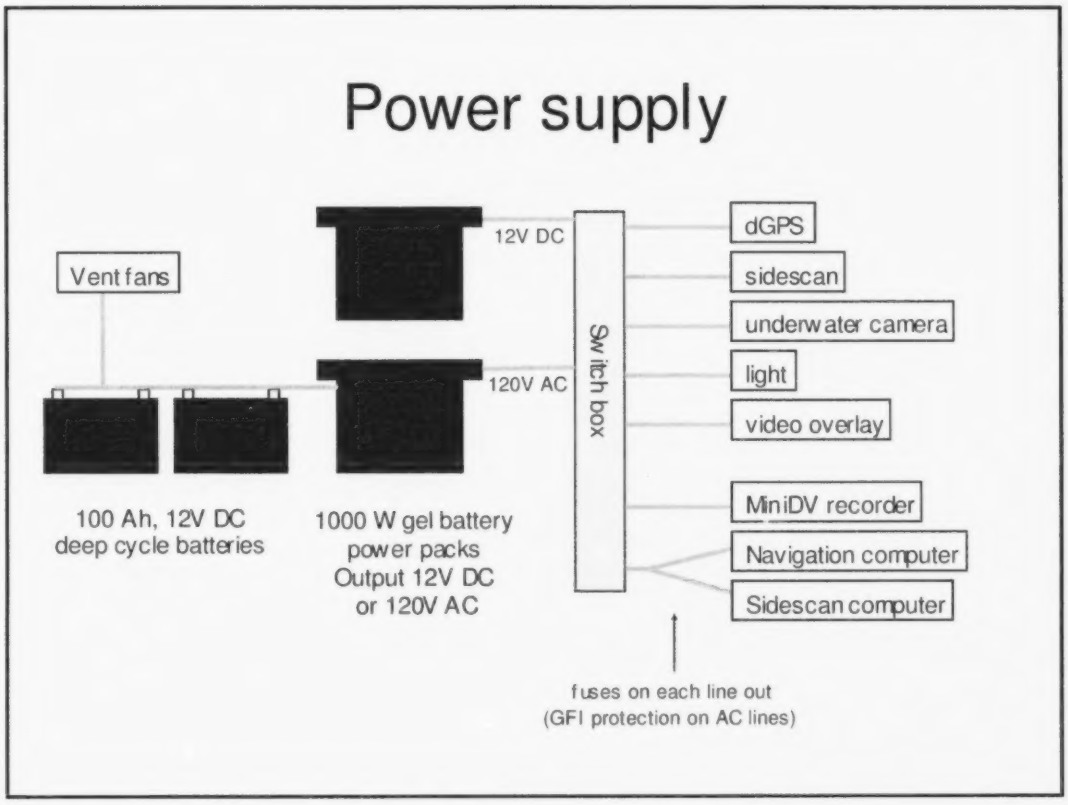

Figure 3: Power supply wiring diagram with a typical array of electronic equipment. Blue lines indicate 120V AC, red lines are 12V DC. The AC lines have the heaviest power demands (mainly due to the notebook computers, about 60 watts each), hence the additional deep cycle batteries.

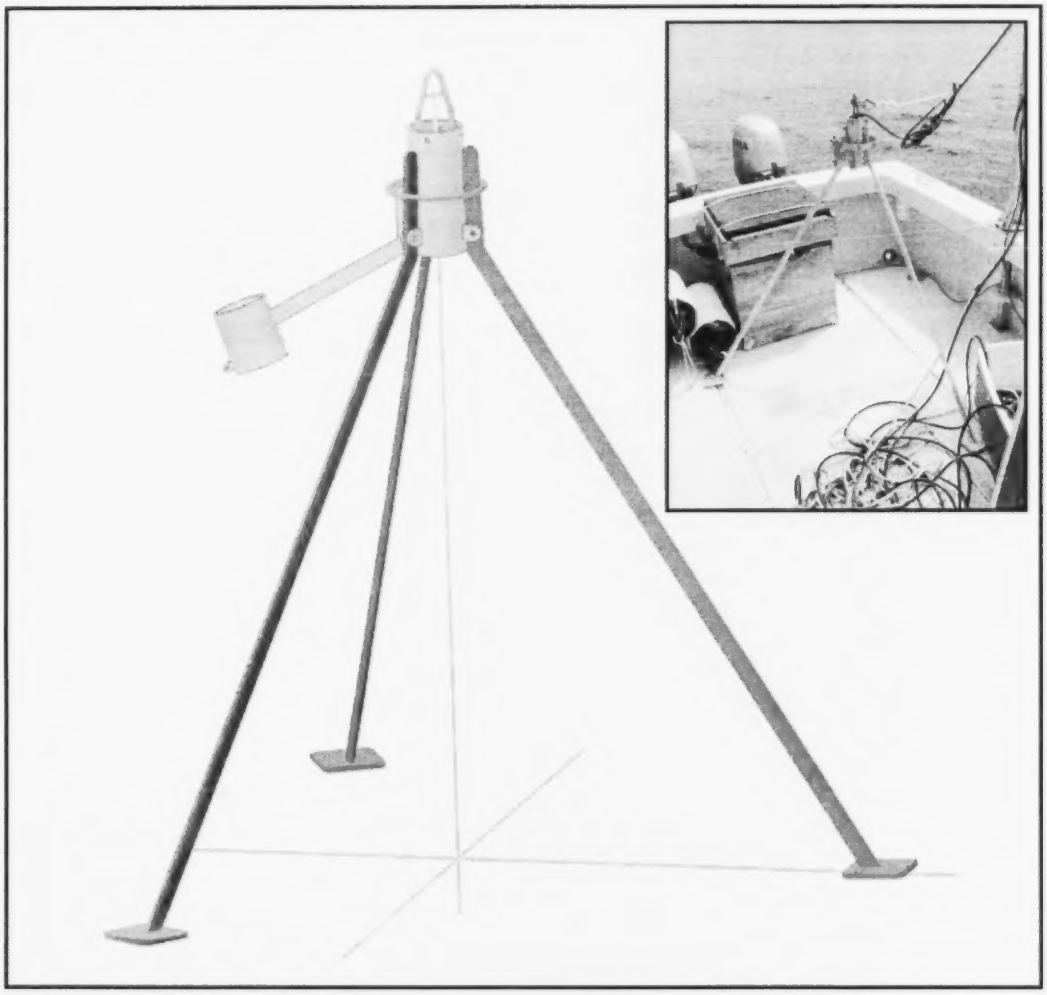

Figure 4: Drop camera tripod. The main camera housing (the tube at the top of the tripod) is 20 cm long. The legs fold in for transport, and are held out via the ring (brown color) for deployment as in this figure. The camera line of sight (vertical green line, 100cm long) allows for a downwards view (green cross at base) when the tripod is on the bottom. The tube on the arm to the left of the camera housing is for a light (130 watts halogen) which is rarely used because of the relatively bright conditions in the shallow waters (<15m) where this camera is routinely used. The nylon deployment rope is attached to the inverted 'V' support at the top of the camera housing via a shackle. The video feed / power cable is taped to the rope at approximately 1 m intervals. Insert: Drop camera tripod on the stern deck with laser mount (yellow plate) just visible on camera tube. Note white nylon rope to support tripod, with black power line taped to the rope. Deep cycle battery box strapped to gunwale.

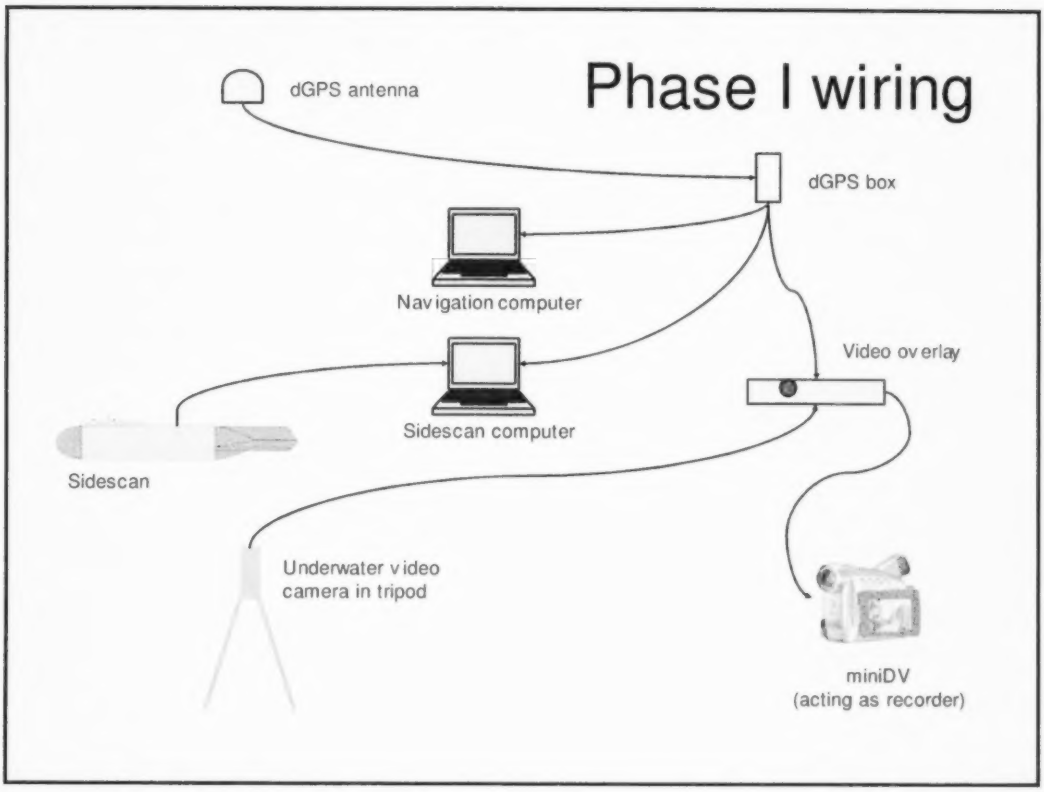

Figure 5: Schematic overview of the drop camera system. The camera tripod is lowered vertically into the water directly under the dGPS antenna on the davit. The transducer section of the sidescan (red tail) is also placed in line with the dGPS antenna via the 'break away' arm mounted at the base of the davit. Sidescan and video camera are not operated simultaneously.

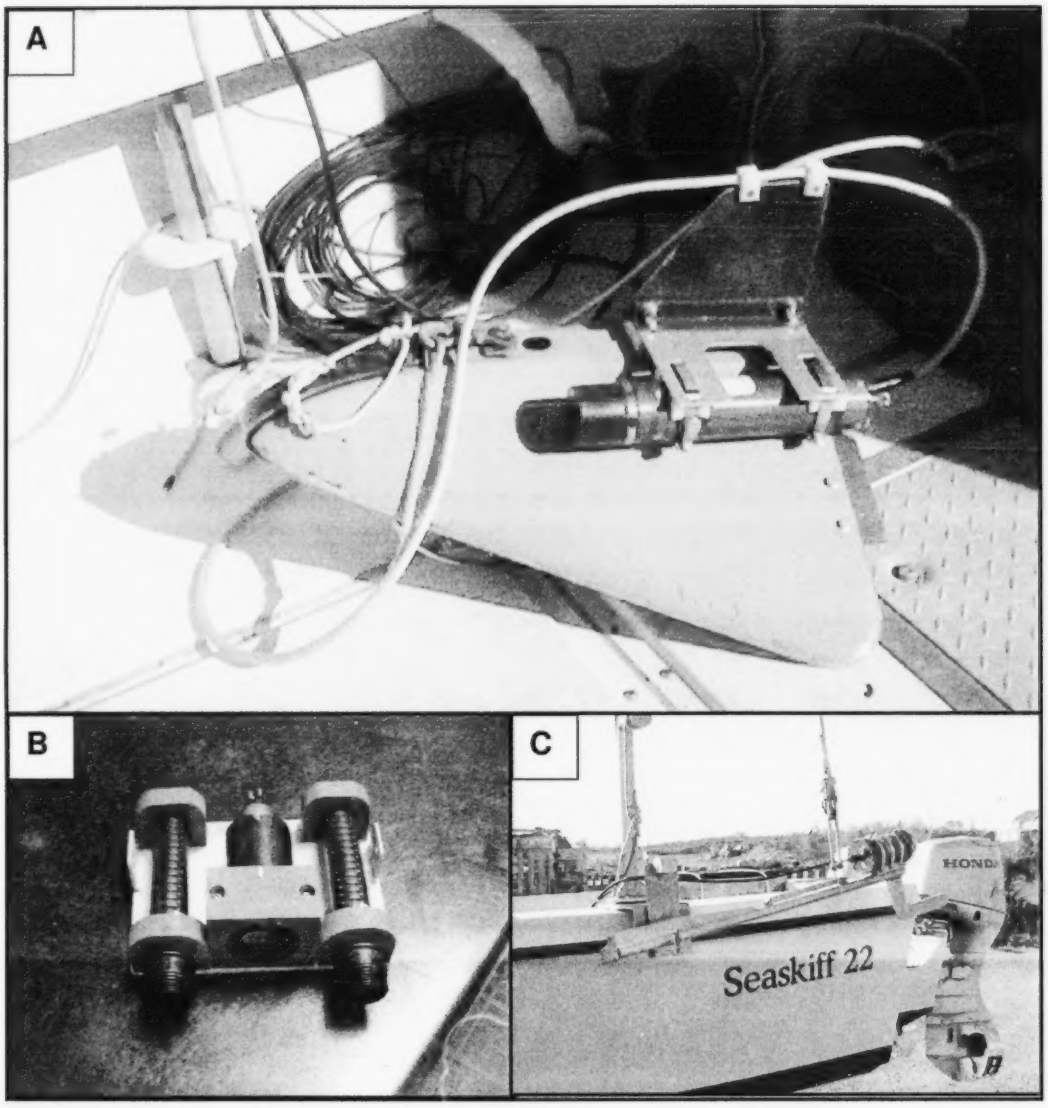

Figure 6: **A** - Towed camera housing made from a depressor wing. The positioning transponder (green tube with black rubber cap, 30 cm long) is attached to the wing via large stainless steel hose clamps through a 'U' shaped aluminum plate bolted to the base of the black dorsal fin. The stainless steel rod cage for the camera / laser holder under the wing is just visible in the photograph. The yellow power / support cable feeds out from the back of the camera and is looped over and clamped to the dorsal fin to prevent excessive vibration as the wing is towed. The yellow polypropylene Kellem Grip for the cable is seen attached to the balance point of the wing by a shackle. **B** - Camera / laser holder. **C** - Break away arm with transceiver attached via large stainless steel hose clamps. Arm has been winched up in transport position. Note 'prop-protectors' on engines, these prevent cable or lines from getting caught up in the propellers.

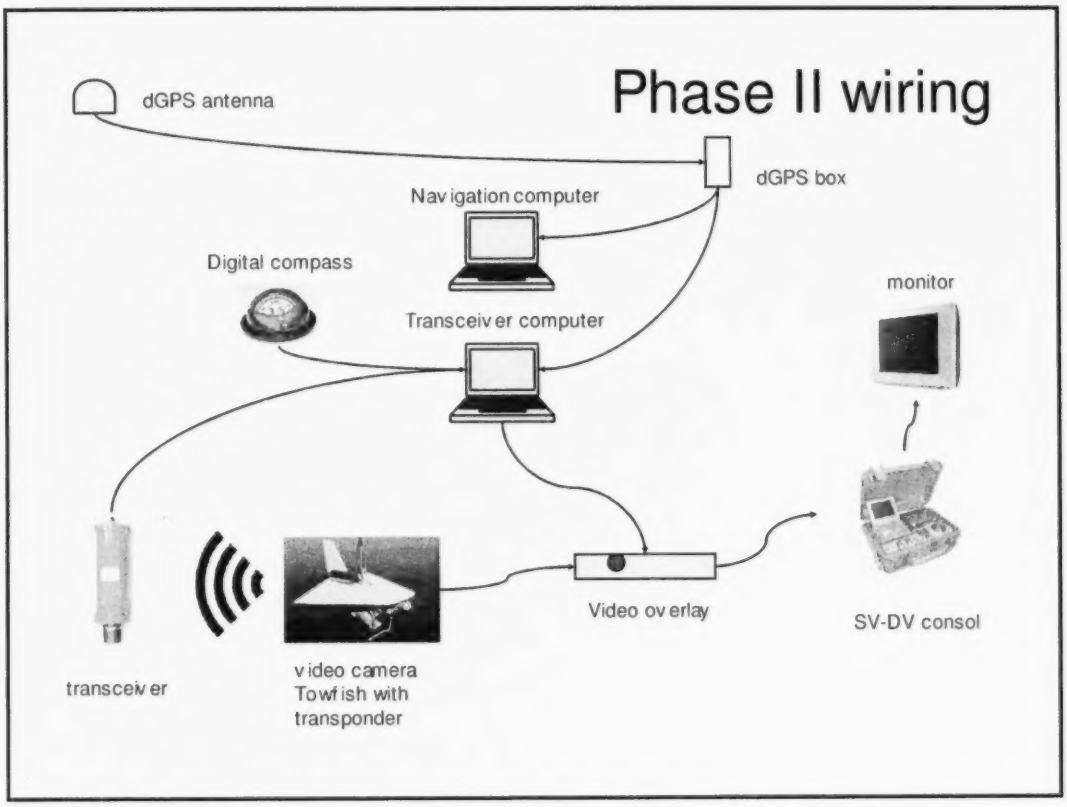

Figure 7: Schematic overview of the towed camera system, a relatively new development (hence 'Phase II'). As per the drop camera, the sidescan and video camera are not operated simultaneously.

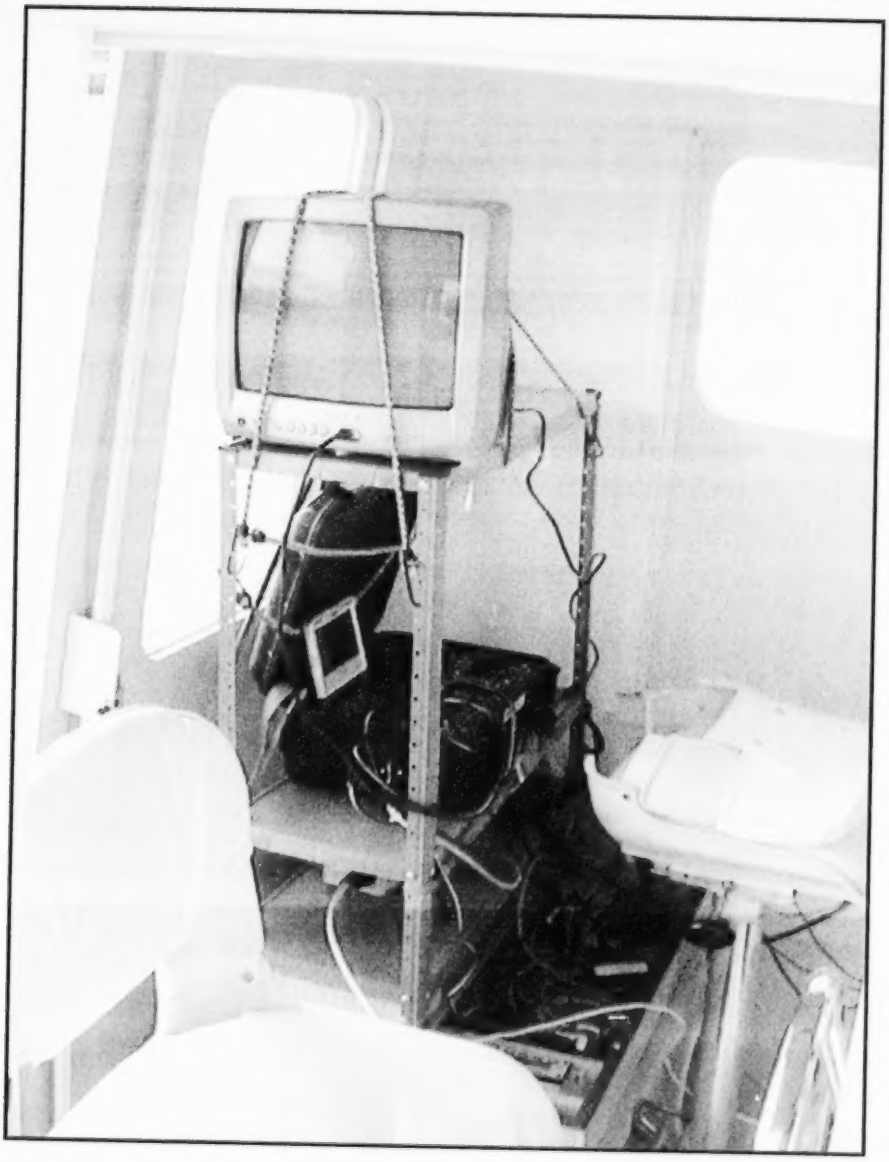

Figure 8: Electronics arrangement in the wheelhouse. Power packs in wooden box as the base, with dGPS electronics and video overlay mounted in the box. A grey metal shelving unit clipped securely to the wooden box base holds additional electronics: bottom shelf for camera feed and computer transformers; middle shelf for miniDV recorder (in this instance the SV-DV consul in a black Pelican case); and top shelf for the video monitor. Navigation and sidescan / transceiver notebook computers are strapped to helm mounts (not shown).

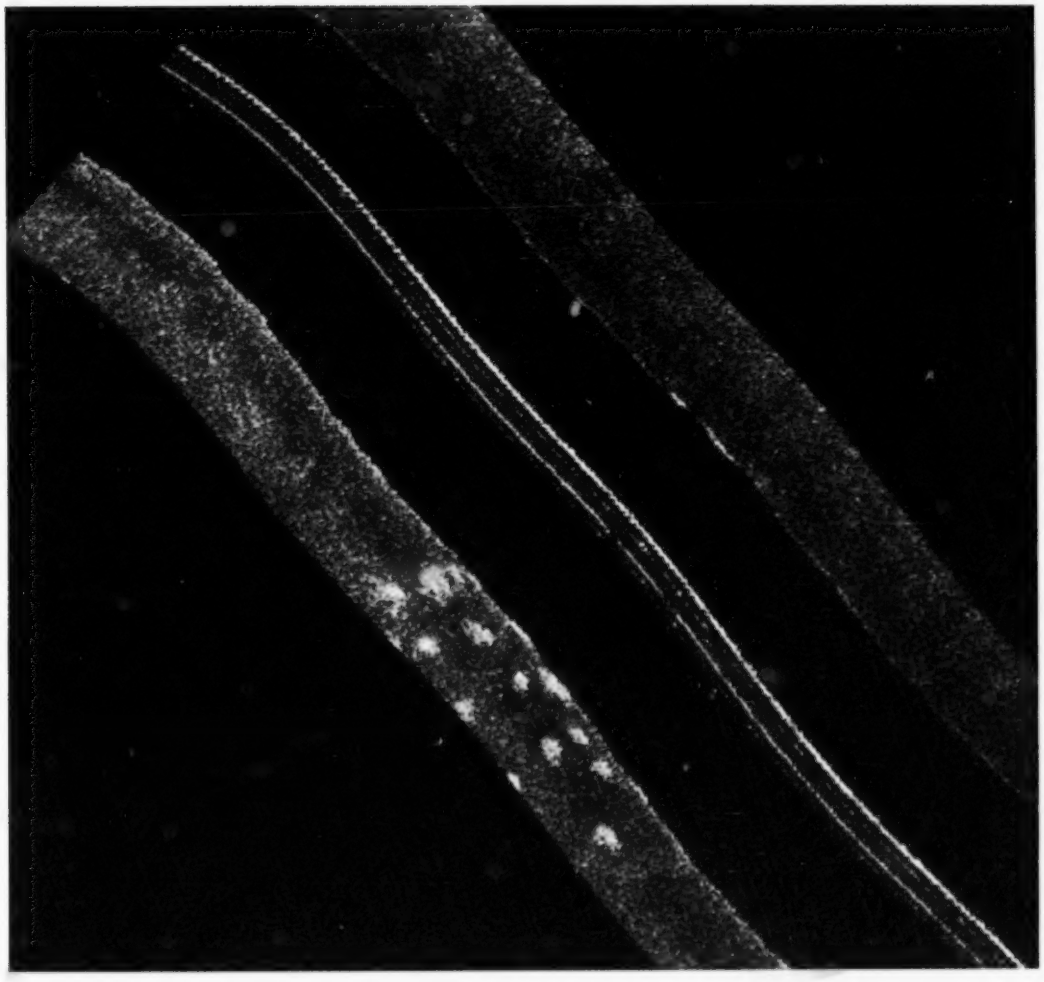

Figure 9: Sidescan image taken from a shallow nearshore area (<10 m) in Sambro Harbor, Nova Scotia. The port transducer indicates a swath of uniformly smooth soft bottom with a low intensity return signal (dark brown coloration). The starboard transducer swath highlights a high intensity return from a hard material (light yellow) resting on the soft bottom. These are rock piles created as artificial reef habitat. Piles are approximately 1 m in diameter. Total swath width (both transducers) is 30 m, 800 kHz transducer frequency, 8 dB gain setting.

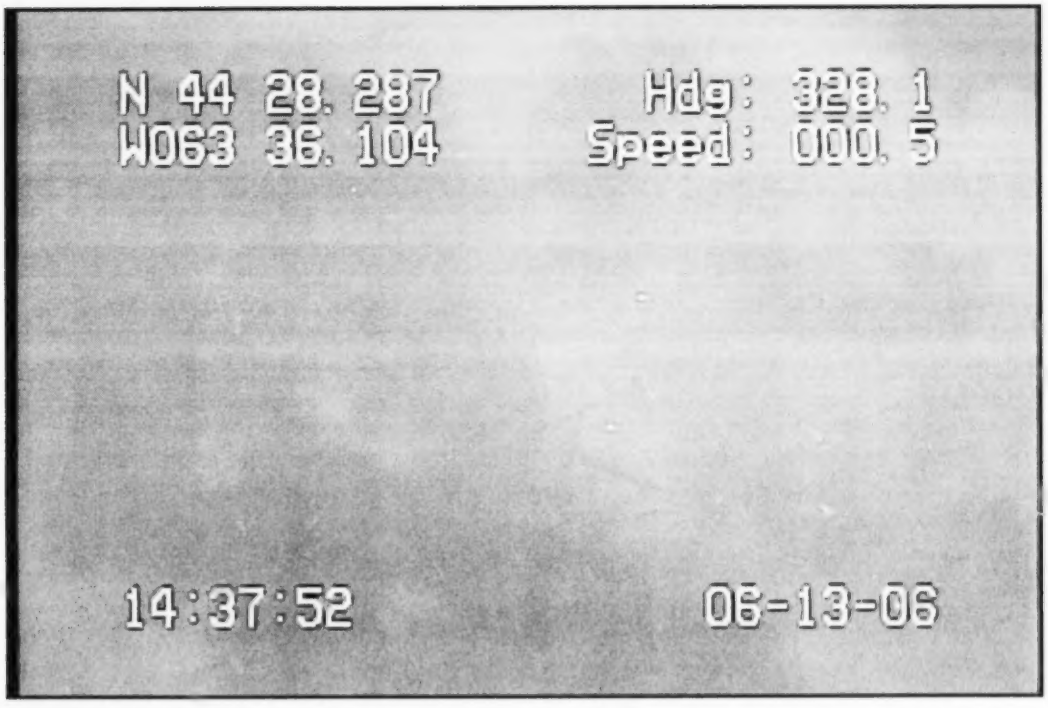

Figure 10: Screen shot of a video clip taken with the drop camera near the artificial reefs in Figure 9. The 10 cm red laser scale is clearly visible. The bottom is sand / silt overlain with drift macrophyte debris. Overlay data, including time and date stamps, direct from dGPS feed (44º 28.287' north latitude by 63º 36.104' west longitude).

Figure 11: Screen shot from a towed camera video made of the Sambro rock reef piles; note the encrusted white sign indicating the reef number. The 10 cm red laser scale is clearly visible (i.e. this reef is one of the 1 m diameter rock piles).